THE FACULTY OF AEROSPACE ENGINEERING AT DELFT UNIVERSITY OF TECHNOLOGY

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Figure 1: The faculty today (Credits: TU Delft) - The faculty in the old days (Credits: TU Delft)

The Faculty of Aerospace Engineering is one of eight faculties at Delft University of Technology. It is one of the most comprehensive academic and innovation communities worldwide focusing on aerospace engineering. Its 120 professors and 70 researchers are mentoring and teaching around 2,800 BSc/MSc students and more than 350 PhD candidates while working in all aerospace disciplines. It's a powerhouse in aerospace education, research, and innovation, within the top 10 in the world. Our priority themes? Sustainable aerospace, digital transformation, including Artificial Intelligence, bio-inspired engineering and smart instruments and systems. Here's our story.

Aviation pioneers

Let's first take a look at the history of the faculty. The official initiation of the aerospace programme in Delft can be traced back to 1940 with the first appointment of a professor in aeronautical engineering. Professor van der Maas held this chair within the faculty of Mechanical Engineering because a separate aerospace engineering faculty was yet to be created, some 30 years later. Logically, the Netherlands would house a dedicated aerospace engineering faculty at its technical universities as the country saw many pioneers at the dawn of aviation. Anthony Fokker is probably the most well-known pioneer, who already successfully flew his first aircraft in the early 1910s. And yet, to date, the Netherlands still possesses large, medium and small (start-up) aerospace-related companies, one of the major airlines worldwide, and the second busiest European airport. Hence, the aerospace engineering faculty is a natural and important contributor to the Dutch aerospace ecosystem.

Educating T-shaped 'can-do' engineers (and beyond)

At TU Delft aerospace engineering, we educate T-shaped engineers: offering a broad BSc and a specialized MSc. We enable lifelong learning through our extensive online courses.

In the BSc students learn a broad range of (aerospace) engineering disciplines. The focus in the first year is on the fundamental tools, such as mathematics, material sciences, statics and dynamics. But just gaining knowledge is not sufficient to be successful. TU Delft aerospace engineering invests a lot of effort in bringing the theory from the lecture rooms to life. This is done by teaching concrete aerospace courses from day one and applying the theory in student projects. Students already learn in the first week of the curriculum why a wing has a sweep angle or not. By the end of the first year, they have already built and tested their first own-designed aluminium wing box. They have to drill, cut, saw, debur and assemble all components themselves in a project team of around ten students.

Figure 2: BSc students designing a new air vehicle (Credits: Guus Schoonewille)

The final project of the Bachelor phase is the Design Synthesis Exercise. This is the flagship project of all Bachelor projects in Delft. This is the time and place where students can bring together all the knowledge they have gained during their Bachelor courses and projects. They work in self-directing engineering teams of 10 students for 10 full-time weeks to solve a relevant space or aeronautical challenge. The students tackle technological aspects, project management, systems engineering, sustainability and engineering ethics. They present their final product to an international jury from academia, research and technology organisations, and industry representatives.

In their MSc students specialize in a number of tracks strongly related to the research of the four departments of the aerospace engineering faculty. There is a mutual influence between the two. And we do not only teach young space and aviation enthusiasts who are physically present on the TU Delft campus. Teaching is also taking place worldwide to online only students through an online education programme: massive online open courseware, professional education and online master courses and programmes.

When the lectures and projects come to a conclusion at the end of the day, some students still spend a couple of hours on the Delft Dream Teams; the D:DREAM, which formally stands for "Delft: Dream Realisation of Extremely Advanced Machines". Our aerospace engineering students collaborate with students from other TU Delft faculties on the realisation of 8+ metre rockets that fly more than 20 km high, solar cars that drive across Australia, personal vehicles that are propelled electrically and all-electric formula student race cars. And these are just a few of the 17 student teams active in the dedicated D:DREAM hall. Students sometimes even do not only work on student projects in the evening hours, but they even take a sabbatical for a while and dedicate their time full-time to, for instance, developing hydrogen-powered general aviation aircraft or drones under the umbrella of AeroDelft or the NederDrone. All these teams have a direct impact on relevant societal challenges.

Research: comprehensive, enabling a systems approach

The faculty is unique in that it covers all the relevant aspects of aerospace engineering: the traditional topics such as structures, aerodynamics, propulsion and performance, but also materials research, manufacturing, noise, climate effects, planetary sciences, aircraft and airport operations, and satellite missions. Interdisciplinary themes we focus on are sustainable aerospace, digital transformation, including artificial intelligence, bio-inspired engineering, and smart instruments.

The research is divided into four departments. Three out of four departments deal with both space and aeronautical topics: Aerospace Structures and Materials, Flow Physics and Technology, and Control and Operations. The fourth department, the Space Engineering department, focuses solely on space-related topics. The aerospace engineering faculty also hosts a research group that is conducting research that is complementary to aeronautical research: wind energy.

Space Research: Earth and planetary observation, access to space

Space is an indispensable part of our everyday life. The space-related research focuses on its capability to

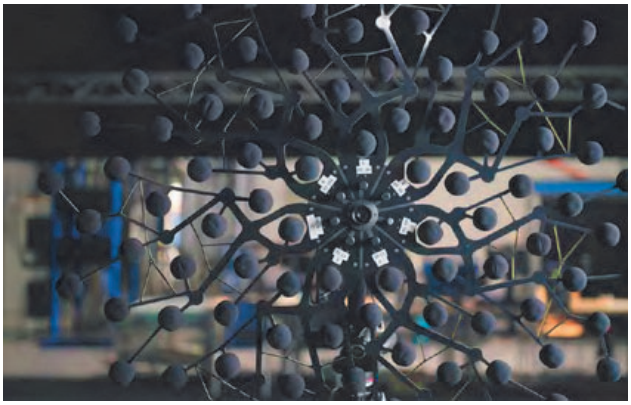

Figure 3: An acoustic camera for noise measurements (Credits: Oculus Film)

contribute to societal needs, such as communication, (near-)Earth observation, and to curiosity-driven research such as solar system exploration and the search for extraterrestrial life. One of the aims of the research portfolio is to make access to space easier, more affordable, and more useful through miniaturization and distributed space systems. Another aim is to make our near-Earth space environment safer for the world's crucial space infrastructure. A further objective is to increase our knowledge and understanding of our solar system and exoplanets. It is vital that we understand how other planets are composed if we want to understand our own planet Earth. The research portfolio includes new and efficient propulsion concepts such as solar sailing. Distributed space systems offer possibilities for mitigating risk but also for observing systems with much needed enhanced spatial and temporal resolution. Distributed space systems bring interesting challenges in terms of for example formation and/or constellation control.

The space-related facilities include a clean room for assembling small satellites, from CubeSats to pocket cubes. Currently, three satellites are active in space: the CubeSats Delfi-C3 and Delfi-N3xt, and the pocket cube Delfi-PQ. Space researchers preparing for follow-on missions that include formation flying. The latest scion, Delfi-PQ, weighs only 0.6 kg with dimensions of 5 x 5 x 18 cm. Finally, there is a rooftop lab with antennae and a ground station enabling tracking of these satellites.

Aeronautical Research: climate-neutral aviation

The aeronautical research is driven by one single goal: a climate-neutral aviation sector by 2050. Delft researchers are convinced that people will want to connect and discover our planet by aeroplane in the future as well. Therefore, they must ensure that this is still possible and does not adversely affect climate change. This massive challenge requires collaboration and multidisciplinary research across all three aeronautics faculty departments and beyond the faculty and university borders. The pertinent challenges are solved using a mix of curio-

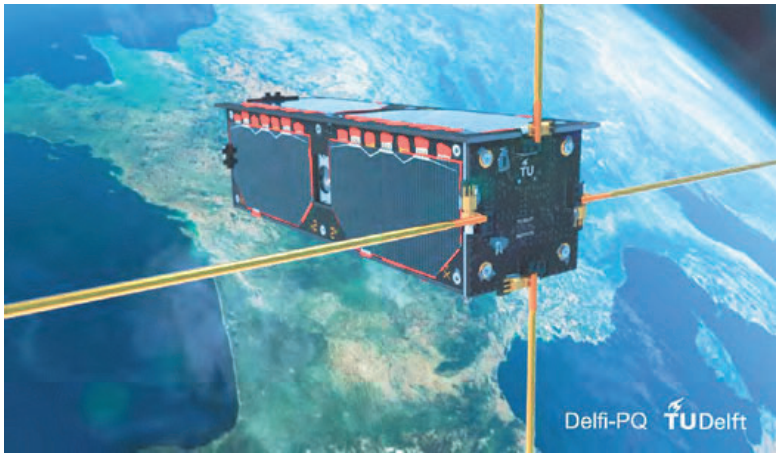

Figure 4: A pocket cube satellite of TU Delft in orbit (Credits: TU Delft)

sity-driven research that generates blue sky ideas and challenge-driven research that tackles the very complex problems that society and industry are facing today and tomorrow. The current Dean of aerospace engineering, professor Henri Werij, made it unambiguously clear in this inaugural address as a TU Delft professor already in 2018: "We have to start the clear sky revolution". The four areas that Delft aerospace has identified for climate neutral flight are a reduction of energy consumption of flying vehicles, sustainable energy generation and consumption, sustainable aviation operations and minimisation of the environmental impact of materials and structures.

Figure 5: The Flying V, a fuel-efficient aircraft configuration (Credits: Guus Schoonewille)

Reduction of energy consumption during flight can be achieved in three ways. The aircraft configuration has to be improved. Novel disruptive concepts are being investigated, such as the Flying V. Furthermore, novel technologies for radical weight and drag minimisation are needed. Such technologies are, for instance, being developed in the SmartX project. Finally, air traffic management operations can significantly contribute by allowing straight flight paths between departure and arrival, and continuous climb and descent profiles. The energy required to fly from A to B must be generated and consumed sustainably. Hybrid electric systems are being investigated for this purpose, as well as green aviation fuels such as synthetic kerosene, liquid natural gas and hydrogen. The operations contribute to the reduction of climate effects by investigating how ground operations are airports can be electrified. Also, airborne operations are analysed and optimised to minimise pollution and noise hindrance around airports. Dedicated climate effect in cruise research is carried out to better understand which parameters do influence the contribution to climate change. As such, recommendations are formulated on which challenges to focus on to fight climate change. Finally, a life cycle perspective on materials and structures is essential. A structure and its material have to be considered from cradle to cradle. Our aim? To create the airframe of the future made of a mix of recycled materials, components, and bio-degradable materials.

Our researchers have a large number of experimental options at their disposal. The Delft Aerospace Structures and Materials laboratory is used to create and bench test novel materials, concepts and technologies. The lab also houses a dedicated scaled flight-testing lab where novel concepts can be flight-tested early on in their development process. Smart automated manufacturing methods are developed and tested in the SAM|XL field lab. When the concepts are manufactured and bench-tested, it is time to go to the wind tunnels. Delft operates wind tunnels from very low speeds of around 30 metres per second to speeds well into the hypersonic flow regime range. A dedicated acoustic wind tunnel can be used to accurately measure the noise. Delft owns a Cessna Citation II research aircraft, which is operated jointly with the Royal Netherlands Aerospace Centre NLR. New

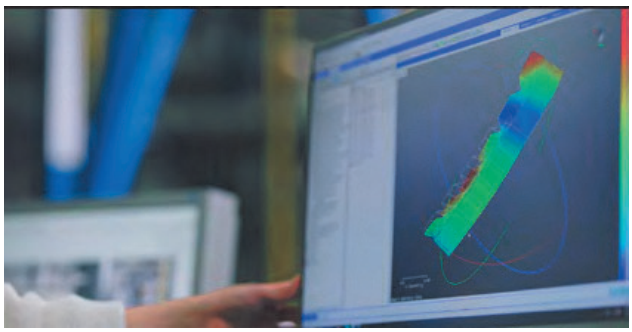

Figure 6: Numerical simulation of the smart wing (Credits: Oculus Film)

procedures and flight control algorithms can be tested with our aircraft. All algorithms are first tested in our full-motion flight simulator, Simona. Finally, swarm and automation technologies of ground-based and flying uninhabited vehicles can be investigated in the 10 by 10 metre "cyber zoo".

Figure 7: An automated manufactured lower shell of the fuselage of the future (Credits: Oculus Film)

Innovation with national and international impact

The cornerstone of the high-quality education and research is (inter)national collaboration, one of the strong points of the faculty. The trinity between education, research and collaboration is embodied in the Aerospace Innovation Hub @TU Delft. The Innovation Hub is hosted in the aerospace engineering faculty building. The hub offers a vast aerospace network and a rich talent pool. Academia, start-up companies, often university spin-offs, and industry meet to collaboratively tackle the societal challenges in space and aeronautics. Another concrete collaborative story is Flying Vision. This concept is both a holistic vision of climate-neutral aviation by 2050 and a physical meeting place on the TU Delft campus that will be opened in 2022. Flying Vision was signed by the CEOs/chairpersons of Airbus, KLM, Schiphol Airport,

Figure 8: The full-motion research simulator SIMONA (Credits: Oculus Film)

NLR and TU Delft. This proves that the desire for neutral climate aviation is supported throughout the entire aeronautical value chain.

The aerospace engineering faculty in Delft does not only collaborate with industry, start-ups and research and technology organisations. Also academic collaboration is high on the priority list. The Universities of Leiden, Delft and Erasmus university from Rotterdam collaborate in the Space for Science and Society programme. This programme was created to exploit collaboration efforts and strengthen cooperation in space-related education and research. In addition to that, the faculty is a member of the PEGASUS network, the network of European aerospace universities.

The only way to solve societal problems related to and by using space and aeronautical technology is by combining curiosity-driven and challenge-driven research, multidisciplinary collaboration across the entire value chain, and training excellent scientists and engineers with this mindset. This is exactly what the Delft University of Technology aerospace engineering faculty offers.

EUROAVIA

By Victoria Maria Prieto – Co-authors: Elena Tonucci and Andrea Curatolo

EUROAVIA is the European Association of Aerospace Students, representing the interests of over 3000 students from 41 universities in 18 countries. Established in 1959, EUROAVIA wants to be a bridge between companies, universities and students. Its goals are:

- To promote European cooperation in the aerospace field by providing opportunities for our members to meet, exchange and learn at all levels.
- To internationally represent European aerospace students.
- To acquaint student members with their future working environment by stimulating contacts with the industry.

THE FOUNDATION OF EUROAVIA

The constitution of EUROAVIA took place in Aachen in March 1959. Representatives from Aachen, Berlin, Braunschweig, Delft, Paris, Milan, Pisa, Stuttgart, and Turin were present at the constituent congress. Together they formed a group of thirty students from ten universities in four different countries. The official statutes were presented and accepted on the 16th of March 1959. Officially EUROAVIA began its work on the 1st of May 1959.

Since the formation of EUROAVIA, many changes and challenges have been faced, but the goals and spirit remain untouched.